NEUTRON YIELD FROM A LEAD-BISMUTH SPALLATION TARGET

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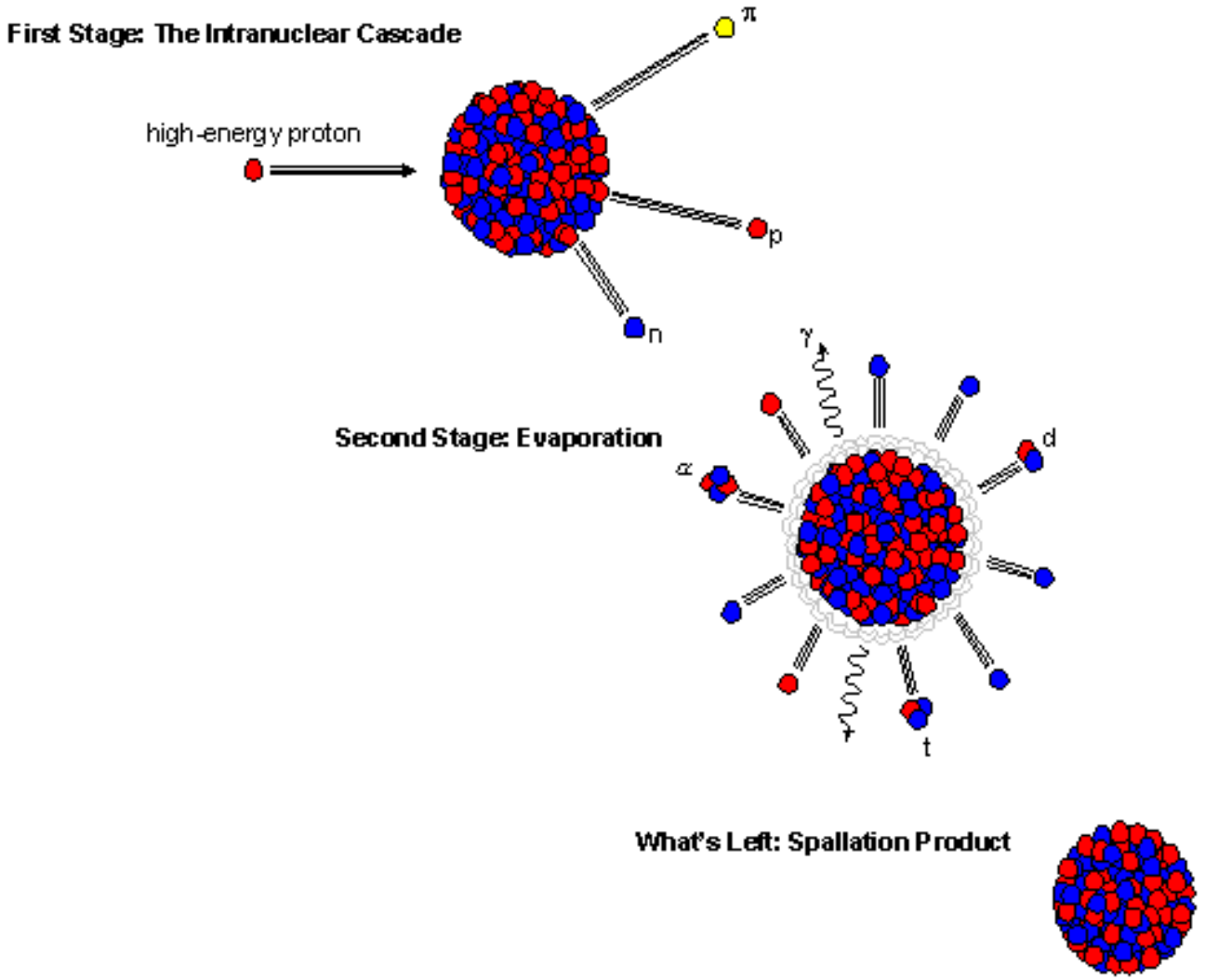
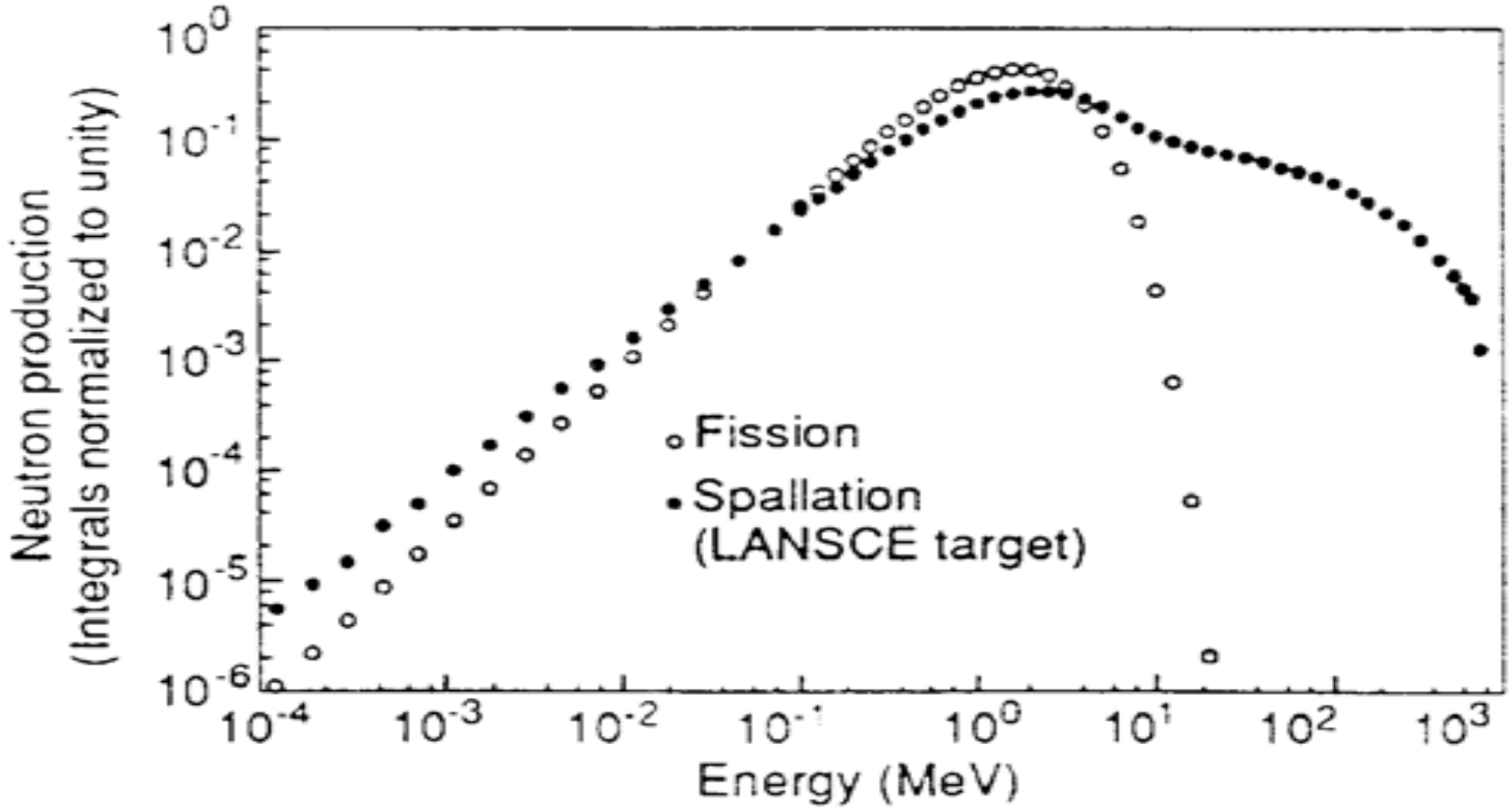
Spallation Basics:
The Process

- Nuclear process similar to fission, but does not necessarily result in two nuclei after reaction
- Occurs when high energy particle (i.e. neutron, proton, pion) collides with a heavy nucleus and deposits energy
- After collision, the nucleus may emit some nucleons, and leaves the nucleus in an excited state
- In de-excitation, the nucleus evaporates and emits many more nucleons, most of which are on the order of a few MeV

Spallation Basics:
The Process



Spallation Basics:
Neutron Energy Spectrum



Experiment Objectives

- Irradiate a lead-bismuth target with 800 MeV proton beam at LANSCE
- Perform gamma spectroscopy on metal foils placed on the target during the irradiation that were activated by neutrons from the target
- From spectrum analysis, determine neutron flux from target both axially and radially
- Compare foil activation results with calculations from the high-energy physics code MCNPX

1. Target Irradiation

- The target was a solid lead-bismuth (44.5 w/o Bi, 55.5 w/o Pb) eutectic cylinder 50 cm long and 40 cm in diameter, and was placed in the center of the beam path
- Foil stacks containing Bi, Au, Co, Fe, In, Cu, Tb, Ni, and Al were attached at axial positions of 0 cm, 5 cm, 10 cm, 15 cm, 20 cm, 30 cm, 40 cm, and 50 cm from the target face along the top
- Foil stacks (without Tb) were also attached every 45… radially at the 15 cm and 40 cm axial positions
- These foils chosen because they contain threshold reactions that will display different regions of the flux
- LANSCE proton beam run at an energy of 800 MeV, a current of about 50 nA, and a duration of 12 hours

1. Target Irradiation

Blue Room Setup

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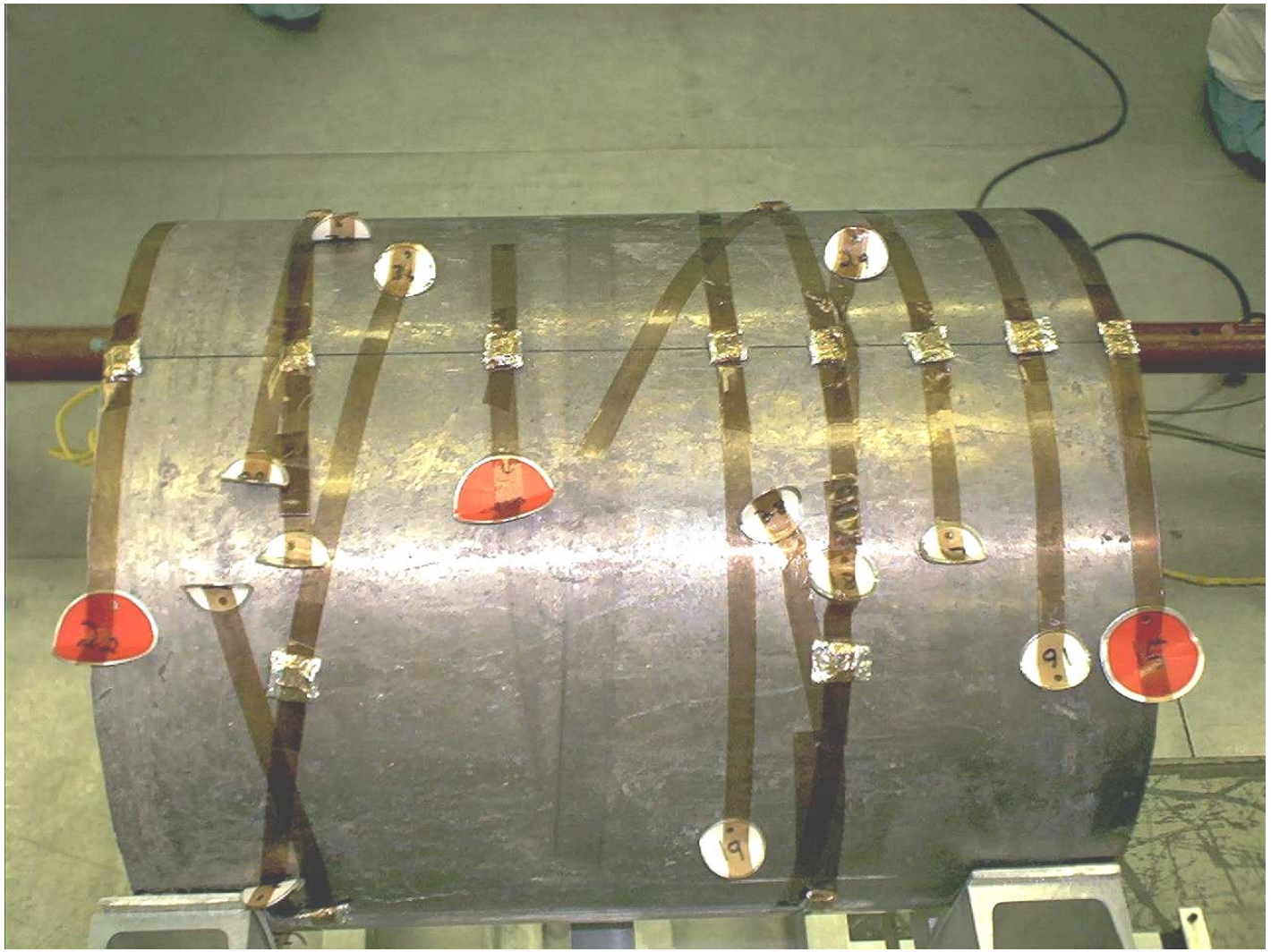
1. Target Irradiation

Foil Placement



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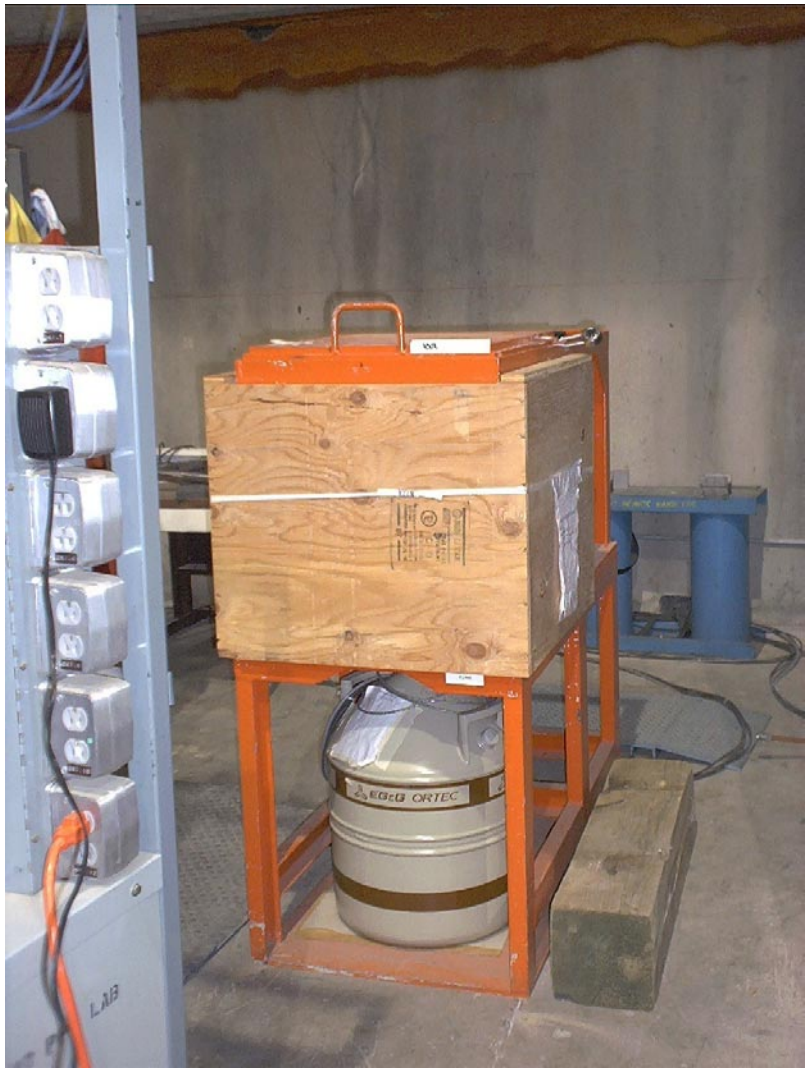
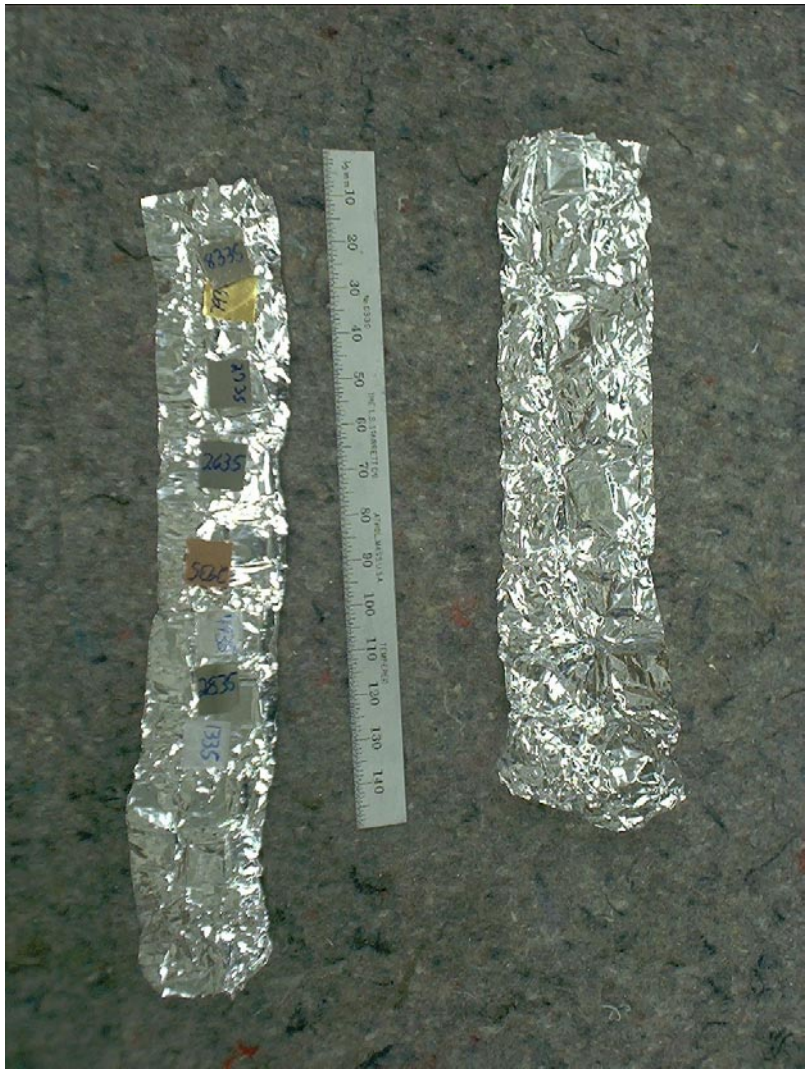
2. Gamma Spectroscopy

- Foils were removed from target after irradiation and moved over to a counting area at LANSCE (some foils also sent to TA-48)
- Two germanium detectors were used to count the activities, and the spectra were recorded with GammaVision
- Foils counted multiple times to observe both short and long-lived isotopes
- Gamma lines for certain reactions identified [i.e. (n,xn), (n,p), (n,alpha), (n,n)]
- Background and calibration counts also performed to identify background lines and determine efficiencies

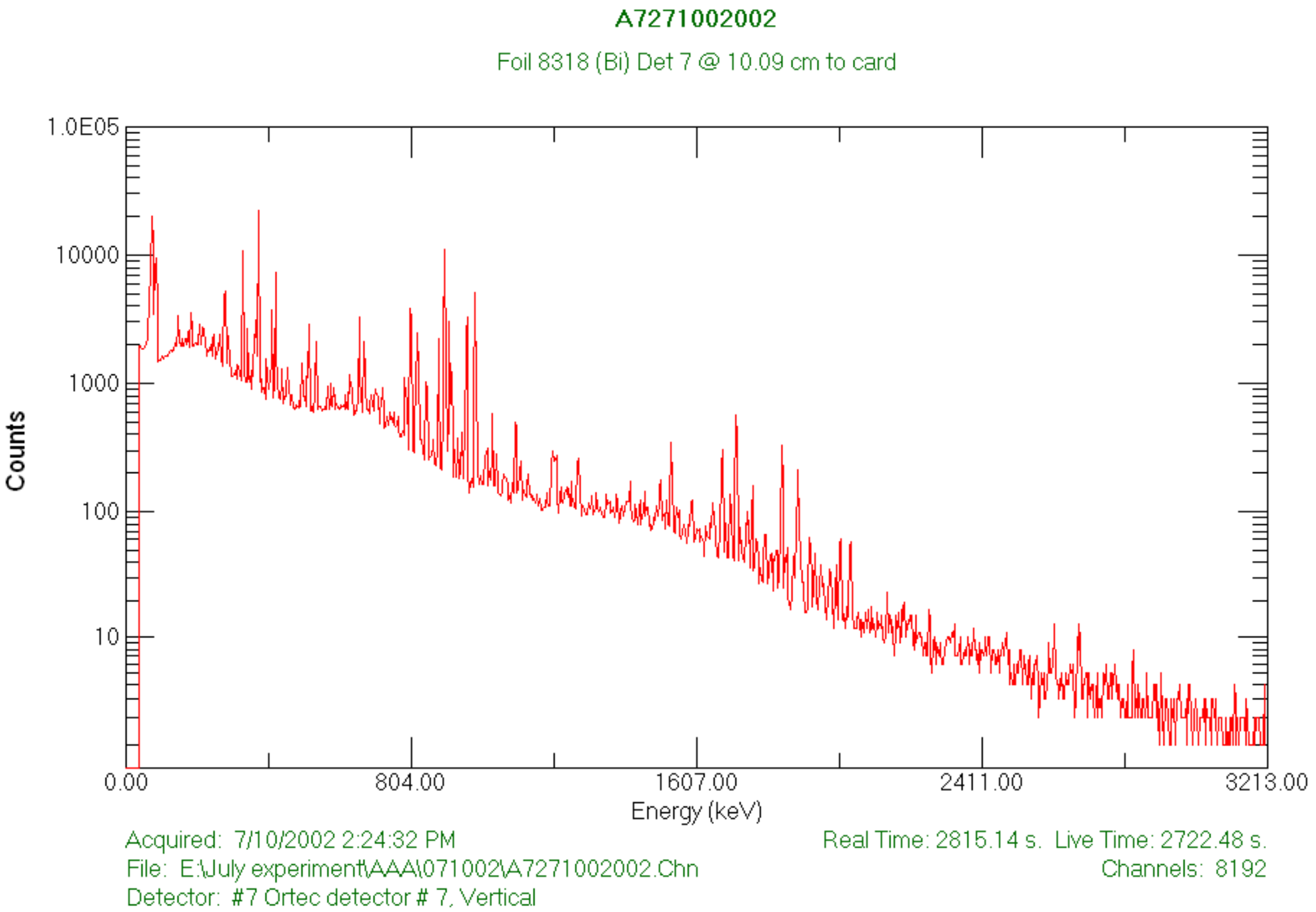
2. Gamma Spectroscopy

Detector and Foil Examples





2. Gamma Spectroscopy
Sample Spectrum



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2. Gamma Spectroscopy
Peak Identification

Isotope (% of foil)	Reaction	Product	Threshold (MeV)	Branching (%)	Gamma Line(s) (keV)	I_g (%)
In-115 (95.71%)	(n,n')	In-115m	0.34	95	336.24 keV	45.8
Bi-209 (100%)	(n,6n)	Bi-204	36	100	374.72 keV	82
					899.15 keV	98
					984.02 keV	59

End of Irradiation Activity (cps/g)

$$A_0 = \frac{N\lambda \exp(\lambda t_1)}{m(1 - \exp(-\lambda t_2))}$$

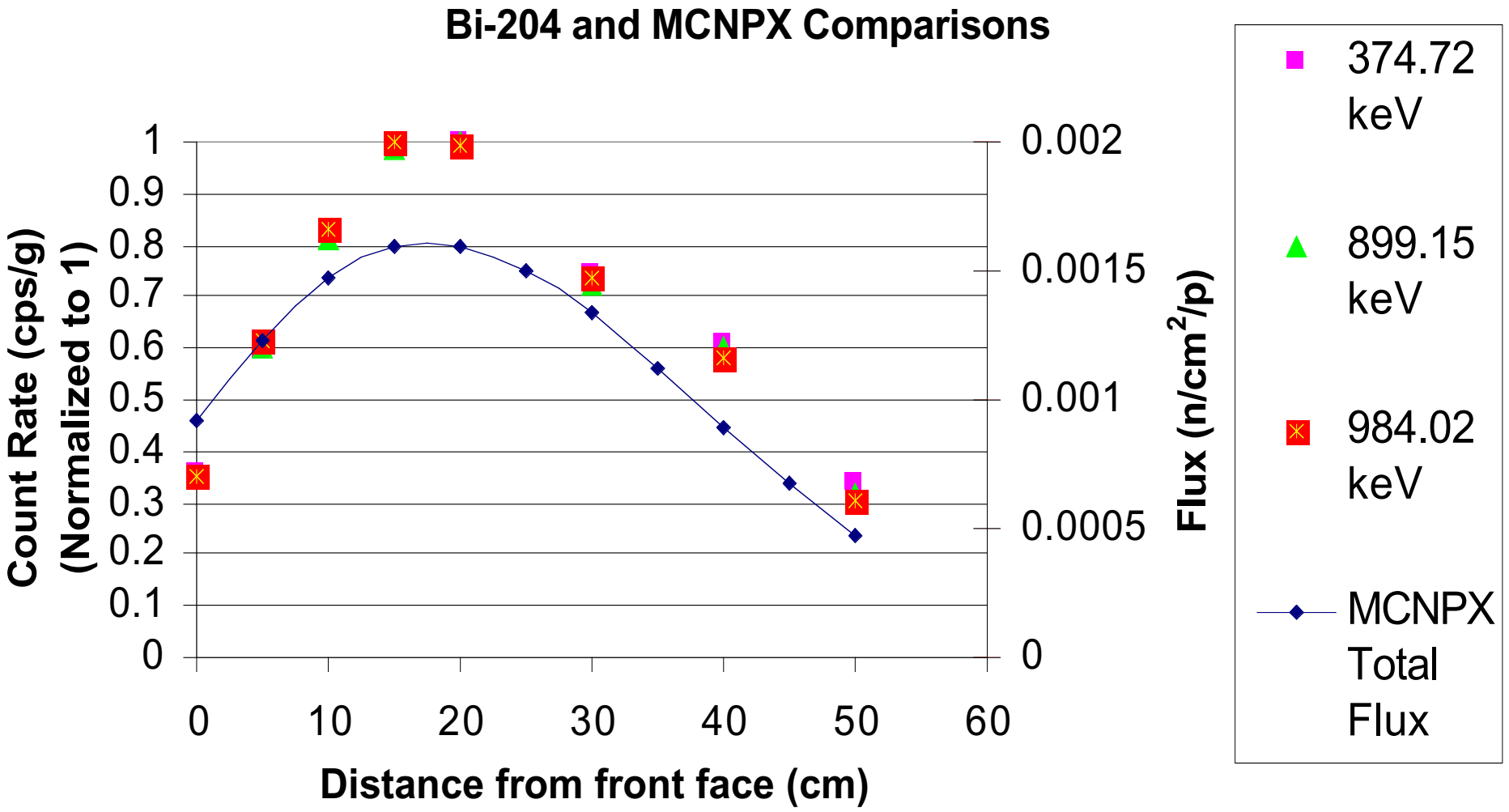
where,

N = net counts in peak, m = mass of foil (g), λ = decay constant of isotope (s^{-1})

t_1 = time from end of irradiation to start of count (s)

t_2 = live time of count (s)

3. Neutron Flux
Axial (Bi-204)



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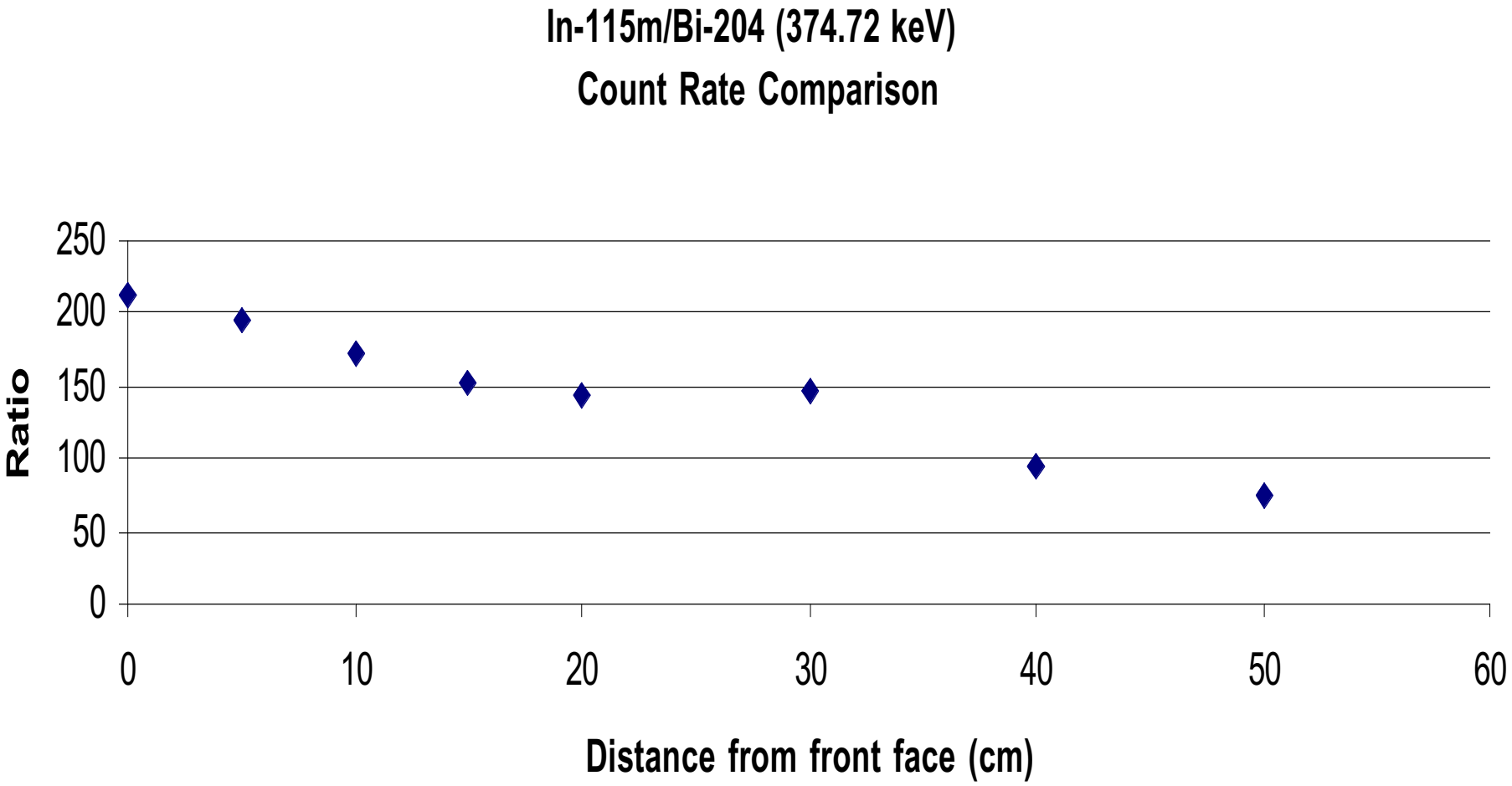
3. Neutron Flux
Axial Comparison



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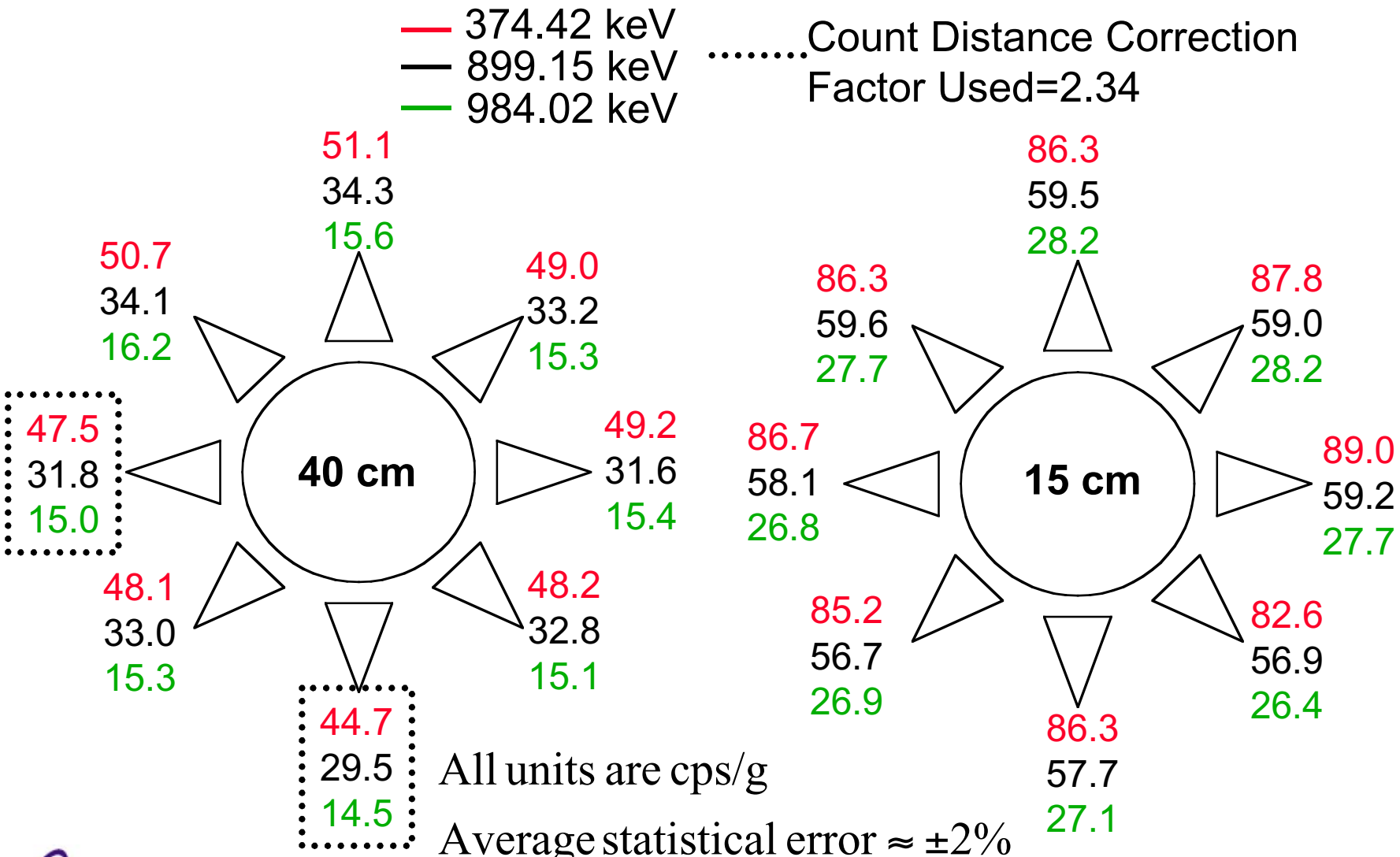
3. Neutron Flux

Radial (Bi-204)



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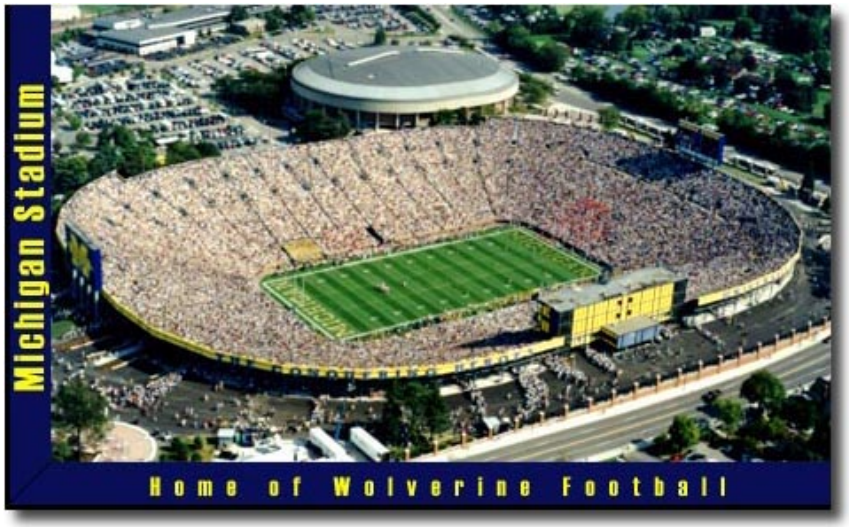
Conclusion

- Foils were irradiated as planned and counting of short-lived and long-lived isotopes is occurring
- Select expected reactions and their corresponding gamma lines were found in the foil spectra
- Axial flux along the top of the target behaved as predicted by MCNPX, with the peak flux shown by the 15 cm foil packet
- Flux was not isotropic radially, the beam appears to have been slightly high and to the right of the center of the target

Future Work

- Work out accurate efficiency curves for both detectors, and investigate background to determine consistency
- Continue to perform gamma spectroscopy on all foil spectra to investigate reactions found in the foils, study half-life behavior, and confirm beam position
- Input activation data into the spectral unfolding code STAYSL
- Go Blue!



Acknowledgements

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